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Gymnocladus in flower

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Cover Illustration---*Gymnocladus* in Flower

The cover illustration shows an inflorescence of *Gymnocladus dioicus*, Kentucky coffee-tree, native to eastern United States. The species is generally dioecious, and this picture shows a spray of male flowers from a very large male tree on the Arboretum grounds. The flower clusters are borne at the tip of the branches.

Gymnocladus, unlike the majority of the Pea family, has regular instead of papilionaceous flowers. There are a tubular 5-lobed calyx, five greenish petals and ten stamens enclosing a short style. The fruit, however, is a legume like the rest of the family. It is a brownish, broadly oblong, flat and thick pod with several large flattened seeds.

Gymnocladus, *Gleditsia* and *Cercis* are the only native woody genera of the subfamily Caesalpinioideae in the Pea family. The other genera are all of tropical distribution. Another point of interest is that it is one of those genera that occur disjunctly in eastern North America and eastern Asia. There are only two species in the genus; the other grows only in central China. *Gleditsia* and *Cercis* are similar in their distribution, except that their ranges are wider, there are more species represented and that the latter is also present in southeastern Europe and Western Asia.

Kentucky coffee-tree is a large tree and has large doubly pinnate-compound leaves. It is useful for bold painting. The tree is so named because seeds were used for coffee west of the Alleghenies before and during the Revolutionary war.

H. L. Li

Trans. to Science 5- -62

The Cultivation of Trees by Mankind

HUI-LIN LI

From the very beginning of the human race, man and trees were intimately associated. Trees, as civilization gradually progressed, became increasingly important to mankind by providing such basic needs as shelter, clothing, and food, as well as drugs, poisons and dyes. Consequently trees played a not insignificant role in the religion of primitive peoples and were one of the most frequently mentioned subjects in early legends and folklore.

Man's earliest associations with trees were, of course, with those of the native forests. At a very early date, however, some trees were deliberately planted, long before any written languages began to appear to record such an event. Most probably, the earliest planting of trees happened at many different times and places independent of each other.

BEGINNING OF AGRICULTURE

As the ice sheets of the last Glacial Age began to recede, some 50,000 years ago, man, the primeval savage, entered slowly into what is now called the Palaeolithic Age. He was then a hunter of foods and he was both carnivorous and herbivorous. Besides whatever animals he could capture with his crude stone implements, all kinds of nuts, berries, fruits, herbs and succulent rootstocks were among his diet. Plants probably furnished more of his foodstuff than animals, and he had apparently acquired some knowledge about plants from his remote arboreal ancestors.

It is generally believed that the present races of mankind appeared some 15,000 years ago, and this marks the dawn of civilization. This is known as the Neolithic Age, as man was able to make more polished stone implements, to produce pottery, and to begin domesticating animals and cultivating plants. He was able also to utilize plant materials for plaiting and weaving.

All these changes that took place were, of course, very gradual and there is no sharp break between one phase of culture and the other. Just how and where man first acquired the knowledge of cultivating plants and utilizing seeds is a story lost in remote antiquity that can never be clearly revealed to us.

We know, however, the Neolithic man in Europe cultivated wheat, barley and millet. He used crude implements made of wood for cultivation. He also ate peas and crab-apples and perhaps also cultivated these in their wild forms.

BEGINNING OF TREE CULTIVATION

The cultivation of certain fruit trees might have begun as early as the cultivation of cereals or might even antedate the latter. This is, however, purely a hypothetical suggestion. Primeval man apparently used wild nuts, acorns and fruits before grain cereals. However, the knowledge of growing plants from seed would be more readily acquired from annual herbs than from trees with a much longer life span.

Although it might be difficult for the primitive man to comprehend the relationship between planting seed with the kind of mature tree eventually grown from it, it should be noted that some trees grow easily from cuttings, a process that can be readily detected. The use of stakes for making protective hedges and of timbers for building shelters and the accidental rooting of some of the materials would soon reveal to the early man the secret of growing and propagating certain trees. Moreover, the early development of weaving and plaiting with such materials as willow twigs which grow readily from cuttings would similarly contribute to such an advancement in human knowledge.

Whatever scattered knowledge on growing plants developed among the primitive peoples could be brought to others by migrations, warfare and other intermixtures. It is the diffusion and accumulation of knowledge that brought about continuous advancement in civilization.

Between some ten to twenty thousand years ago, as the primitive man developed agriculture and gradually settled down to food-producing instead of food-hunting, a great change occurred in the living conditions of mankind. Settlement began in small communities which made possible more rapid development of various phases of human civilization. With these settlements, trees were planted to afford shade and protection, to provide edible fruits and nuts, and to furnish symbols for worship and as memorials. Naturally grown trees of great size or age or of high yield in fruit were probably first singled out for preservation, but later trees were deliberately planted for these purposes.

The Tree of Life

Trees were frequently mentioned in the Bible. The second chapter of Genesis says, "And out of the ground made the Lord God to grow every tree that is pleasant to the sight, and good for food; the tree of life also in the midst of the garden, and the tree of knowledge of good and evil."

The tree of life conferred on man immortality. The tree of knowledge gave the power of distinguishing good and evil. One was moral and the other prophetic, the sign of the first revelation to man. They belong to paradise and were intended to teach the primitive man in moral duty, and in his anticipation of the world to come. (Fig. 10).

Fig. 10. Many versions of the "tree of knowledge" are depicted in publications of all ages. This one is from the herbal *Ortus sanitatis,* 1491.

We are now obliged to connect the early chapters of Genesis with the old beliefs of Babylonia. In another ancient civilization farther east, in China, the tree of life can also be traced in their ancient traditions. In the writings of the philosopher Li-tze, who lived about 450 B.C., there is mention of the Fairy Islands in the eastern ocean, a paradise of gold and jade palaces, beauteous birds and trees whose fruits confer immortality. (Edkins 1889).

Trees for Worship and as Memorials

Trees are thus associated with the earliest religious belief of man. In ancient times among all peoples trees of massive size and great age became mystical symbols and subjects of worship. In the mythology of all races, trees are very frequently mentioned. Even to this day old trees are often still worshipped or revered among peoples of more primitive culture or more superstitious beliefs.

In the Scriptures trees are mentioned not only for use as ornamentals but were also planted, as is still the case in cemeteries, as memorials. Later on in Roman days, Pliny observes, "In old times trees were the very temple of the gods; and, according to that ancient manner, the plain and simple peasants of the country, savouring still of antiquity, do at this day consecrate to one god or other the godliest and fairest trees that they can meete withall; and verily, we ourselves adore, not with more reverence and devotion, the stately images of gods within our temples, the very groves and tufts of trees, wherein we worship the same gods in religious silence." (Holland's translation of Pliny's "Natural History", p. 357).

Pliny goes on to say, "The ancient ceremony of dedicating this and that kind of trees to several gods, as proper and peculiar to them, was always observed, and continuous to this day. For the mighty oak, named esculus, is consecrated to Jupiter, the laurel to Apollo, the olive to Minerva, the myrtle to Venus, and the poplar to Hercules."

In the Far East the use of trees as memorials also began very early. In the Chou dynasty (1122-240. B.C.) long traditions had already established the five official memorial trees for the tombs: pine for kings, arbor-vitae for princes, Sophora (pagoda tree) for higher officials, Koelreuteria (China-tree) for scholars, and poplars for the common people. (Figs. 11-14).

Fruit and Nut Trees

The origin of cultivation of many of our common fruit trees is lost in antiquity. Their domestication began in prehistoric times and

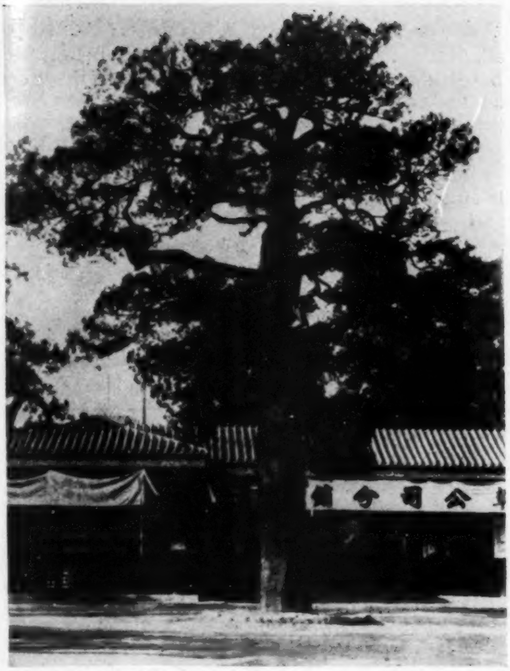

Fig. 11. An ancient Juniper planted in Central Park, former imperial garden, Peking, China. (From *Journ. Arnold Arb.*, 1926).

thus it is now impossible to trace back to their ancestral forms. In some cases the wild ancestral species are probably still extant, but they bear only remote resemblance to the cultivated types which have changed greatly under long cultivation. In most others the original wild types are long extinct. There may be occasional claims of discoveries of the wild types of certain of our long domesticated fruit trees, but these are often only naturalized escapes of cultivated plants and not spontaneous wild forms.

The absence of wild prototypes of some of our common fruit trees, like many of the cereals, attests to their great antiquity. Such fruits as apples, plums, pears, peach and cherries are among the earliest cultivated plants of man. These fruit trees originated in two major centers corresponding to the two great centers of civilization of the Northern Hemisphere: Eurasian, that is Western Asia and Europe, and eastern Asia. Among the different apples, pears, plums and cherries, there are Eurasian groups as well as Chinese groups of each kind. There are also grape, fig, date-palm and others of Western Asiatic origin and peach, oranges and others of eastern Asiatic origin only.

Some general ideas about the process of early cultivation and domestication of these fruit trees, long lost in antiquity, can be gained by observing the development of fruits in the New World in recent history. In temperate North America, there are many wild species of *Prunus* and *Vaccinium* and other genera that bear edible fruits. The introduction of these trees into cultivation began only in the last one to two hundred years. Out of the very many species, a few have proved to be promising fruit trees, such as plums, blueberries and cranberries, but others such as native apples, cherries and other berries have found to be of little or no value. Thus, although many species are available and tried out at first, most fall into disfavor in one way or the other. Gradual elimination will eventually leave only a few of the most worthy ones. These by intense selection and improvement, will ultimately become so different from their wild prototypes that their relationships may be difficult to recognize by the future generations. The general course of development of fruit trees in the Old World in prehistoric time is undoubtedly similar.

Acorns and nuts must have been used by man since the remotest times. The remains of the Pekin man, living some 100 thousand years ago in northern China, show that hackberries were already used as food. The improvement of nut trees under cultivation, however, has not been carried out as far as the edible fleshy fruit ones.

Fig. 12. Old trees of Arbor-vitae in Central Park, Peking, China. (From *Journ. Arnold Arb.*, 1930).

The most valuable and widely used nut of the whole world is the cocoa-nut, a maritime palm of the tropics. There are many other nut trees in the tropical and subtropical regions of the world. The most important nut of the temperate world is the walnut, *Juglans regia,* a native of Central Asia to southeastern Europe. Other important nut trees of the North Temperate Zone are chestnuts, hazel-nuts and almond. (Fig. 15).

For further details on the origins of the various fruit and nut trees, the interested reader can consult such authoritative treatments by DeCandolle (1884) and Vavilov (1926, 1951).

Trees for Shade and Ornament

In nearly all cases the ancestral forms of cultivated shade and ornamental trees are still known. This shows that the planting of trees for shade and ornament began later than fruit trees. These trees, as compared with fruit trees, are less variable, indicating also their relatively shorter history. Furthermore, the parentage of most of the hybrid trees originated in cultivation can still be clearly traced.

In the Scriptures, trees planted for ornament are frequently mentioned. Solomon, for instance, transplanted cedar to the plains from the mountains. The cedar is, in the book of Ezekiel, to be frequent in magnificent gardens.

Fig. 13. Cryptomerias on temple grounds, Nikko, Japan. (From Elwes & Henry, *Trees Gt. Brit. & Irel.,* 1906).

Fig. 14. A huge Yew tree in a church yard, Tisbury, England. (From Elwes & Henry, *Trees Gt. Britain. & Irel.,* 1906).

Reliable information on trees known to the ancients, down to the time of the Greeks, is to be found in the works of Theophrastus. Many of the plants mentioned by him were identified by Sprengel (1808). Sprengel's identifications were subsequently revised and amended by Stackhouse in his edition of Theophrastus' *Historia Plantarum.* A list of not less than 170 ligneous plants selected out of this work is given by Loudon (1838). These include many trees and shrubs native to Greece and also others such as peach, persimmon and cherry which were introduced from other countries. While most of the plants are economic ones, a number of the trees valued mainly for shade or ornament, such as elm, plane, beech and alder are also listed. (Figs. 16-17).

The writings of the Romans contain the knowledge of all the trees possessed by the Greeks but to this are added also the trees of the colder regions of Europe. Among ornamental trees, the pine, the bay, and the box appear to have been favorite trees of gardens. Many other trees were planted for various useful purposes such as for their wood and fruit, or as fuel and other usages. The most reliable source of information on trees of the Romans may be found in Pliny's "Natural History." The species mentioned in there were also identified by Sprengel.

In ancient China, the highways of the Chou dynasty (1122-240 B.C.) were famed for their smoothness. These highways were known to be lined with trees. During the short-lived Ch'in dynasty (221-206 B.C.), China was unified for the first time as a single empire. The Emperor, Shih-Huang-Ti, had military superhighways built from the capital for thousands of miles in all directions to the border. These highways are

said to be fifty feet wide and were built by removing hills and filling seas to make them straight. They were all lined with pine trees. Besides pines, the trees most frequently used for street and avenue planting in ancient China were willows, Sophora, chestnut and elm.

Selection and Improvement

In cultivating plants, man has from the very beginning striven to improve on their products. In edible fruits, efforts are made to improve upon their size and flavor. In flowers, improvements are aimed at their size, color and shape. In ornamental and shade trees, it is aimed at better shape and healthier growth. In the interim of this continuous process of improvement through the centuries, new varieties appeared under various species and were preserved and propagated. The cultivated plants are one of our most cherished heritages from the past, the result of unceasing toils of endless generations of farmers and gardeners through the entire history of mankind.

Man has for centuries taken advantage of certain natural laws, without actually being conscious of, in furthering his efforts in improving his cultivated plants. Nature creates variations in plants by inserting new genetic factors (genes) into the inheritance mechanism, by causing new and abrupt changes (mutations) in these genetic factors, by altering the original setup of this mechanism (chromosomal changes), and by crossing different genetic stocks (hybridization).

Aside from effects of environment which are not heritable, these genetic changes result in creating differences among plants. No two individuals in nature are exactly alike. The differences vary from very slight and subtle ones to something quite drastic. This is called variation in genetics, the science of the study of heredity. Variation is the basis of natural selection which brings out the very complex phenomenon called organic evolution. Taking advantage of this same basic fact, variation, the keen farmer or gardener selects the one plant out of a thousand that possesses certain desirable features and plants and propagates it. This is called artificial selection or plant breeding which has been carried on through generation after generation and has produced the cultivated plants we have today.

Thus before modern genetics became a science toward the end of the nineteenth century, improvement on trees had already been done to a certain extent. In most of our common tree species there are a number of varieties and these have been mostly developed in cultivation. Many new hybrids have also been raised and maintained, especially among genera with species distributed naturally in disjunct areas and brought together in cultivation in modern times. Such geographically isolated and genetically related species often readily produce hybrids such as in *Aesculus*, the horsechestnuts and *Tilia*, the lindens. Hybrids, if fertile and bred among themselves or with their parent species, will not produce constant progenies but will show all intermediate characters ranging from one parent to the other. In other words, hybrids will not breed true to type. In tree cultivation, however, the advantage of vegetative propagation can overcome this difficulty. The progenies of a single individual, including those of hybrids, thus propagated, are all uniform in their characters, producing a line technically called a clone, and thus all desired characters of that individual can be perpetuated and multiplied.

Fig. 15. Walnut in Barrington Park, England. (From Elwes & Henry, *Trees Gt. Brit. & Irel.*, 1906).

In some such hybrids, when effected by certain internal changes, the entire complement of the inheritance mechanism (chromosomes) may become doubled. In this way the plant will subsequently be able to breed true from seed, in fact giving rise to what sometimes is called a "new species". Among the trees an example is *Aesculus* × *carnea*, the red horsechestnut, a hybrid between the common horsechestnut, *A. Hippocastanum* of Europe and the red buckeye, *A. Pavia* of North America. Both parents have a chromosome number of forty, but the hybrid has the number of eighty.

The chromosome number in a given species is normally constant. All cells of the plant carry the same number of chromosomes with the exception of the gametophytes and gametes, the gamete-producing generations and the reproductive cells respectively, in which the number is reduced to one-half. The male and female gametes eventually unite to produce the new embryo and seedling. With regard to chromosomes the number in the embryo and consequently in the mature plant is known as diploid, meaning two sets, and the number in gametes as haploid. When the gametes unite to produce the new embryo, the haploid number is restored to diploid, thus completing the cycle.

Fig. 16. A Yew avenue at Midhurst, England. (From Elwes & Henry, *Trees Gt. Brit. & Irel.*, 1906).

Changes in chromosome number occur frequently in nature for various undetectable reasons. The change may involve the addition of one or a few more chromosomes (aneuploidy). It may be multiplications of entire sets of chromosomes (polyploidy) such as the addition of one, two, three, etc., sets to the original two (triploid, tetraploid, pentaploid, etc.). It is now found that such a change in chromosome number can sometimes be induced by artificial means such as treating with colchicine.

All such changes in chromosome numbers, like all other changes in the basic genetic pattern (genotype), bring corresponding changes in the appearance of the individuals (phenotype). Whenever new and desirable characters of heritable nature appear, characters due to genetical and not environmental effects, the keen plant breeder will have a chance to select and perpetuate.

Professor Zirkle (1935) has traced very lucidly the history of plant hybridization in former times in his book *The Beginnings of Plant Hybridization*. He thinks artificial pollination was invented very early, probably antedating the invention of writing, as authentic records of pollination extend back to Babylonian times. Many fruits, such as the date-palm and the fig, were hybridized by the ancients in prehistoric times, though only incidentally. But in ancient and medieval times, the sexes of plants were not clearly known and gardeners and agriculturists on the whole were ignorant of the function of pollen. Thus spontaneous hybridization was not early recognized, and was explained as spontaneous degeneration. Accurate accounts of plant hybridization date from the first half of the eighteenth century, but it was apparently practiced earlier. Most of the hybrid trees are developed, recognized and selected since that time.

Dispersion of Cultivated Trees

Plants were known to be deliberately transplanted by men since the earliest historical times. Abraham brought trees from other lands for planting. Solomon collected all kinds of plants and he not only had an orchard of fruit trees but also planted on his ground what were called barren trees; among these the cedar was apparently brought from the mountains.

The earliest historic record of foreign plant introduction is in the fifth Egyptian dynasty, dated by modern historians as around 1570 B.C., when Queen Hatshepsut brought foreign seeds and plants from the land of Punt — generally believed to be the east coast of Africa. She sent her ship to this foreign land for seeds and trees so she might produce the aromatic incense in her own gardens. She caused sculptors to accompany the expedition, and, returned, they carved and set up a bas-relief at Luxor showing gardeners loading the boat with incense trees in tubs and piling its decks with seeds.

One of the seven wonders of the ancient world is the Hanging Garden of Babylon of the third century B.C. It was planted with exotic flowers, trees and lianas. Pumps worked day and night to water this celestial garden, which towered 430 feet into the air. The garden was built by the King of Assyria as a pleasure seat for his queen Shammuramat, whom the Greeks called Semiramis.

In China, records state that at the death of Confucius in 481 B.C., his disciples, reputed to be 3,000 in number, planted trees in his graveyard as memorials, all brought from their native regions far and wide. This may be called the first arboretum on record, a garden of trees and not just a park or orchard. In ancient China, records of tree introduction from foreign lands by various emperors are quite numerous. Many monarchs built extensive gardens and had trees transplanted from distant lands. In the second century B.C., Emperor Wu-ti of the Han dynasty, for instance, had Litchi transplanted, though unsuccessfully, from the newly conquered Annam to the capital in northwestern China.

The story of plant dispersion and introduction has been carried on through all ages and in all countries. Plant introduction has been carried on so naturally and so gradually that few people, even historians, realize the importance of its role played in the advancement of human culture. The processions of restless and wandering men have for centuries carried with them seeds and plants, favorite vegetables or fruits or trees that harbor a longing of nativity. Plants have been transplanted from point to point on the earth for food, beauty or mere sentiment.

Relatively few records of plant introduction, however, are recorded in historical chronicles. Numerous instances of introductions, deliberate or accidental, made by merchants, travellers, pilgrims and adventurers, or brought about by migrations and invasions, never entered into any writing. Our study on plant dispersion has to be made largely by inferences based on circumstantial evidence.

In plant dispersion, the most important route in ancient times was the trade route known as the Silk Road connecting the two great centers of civilization in the East and the West through the deserts of Central Asia. Peach, orange and some other fruits were carried from China to Persia in very early times. Grape, pomegranate and others were brought from there to China around the second century B.C. The weeping willow reached Babylonia from China through the same route at an unknown date. After the tenth century, contacts between the East and the West, in addition to this overland route, were also effected by merchant ships sailing across the Indian Ocean.

The discovery of the New World initiated an age of great plant migration. The beginning of this important chapter of human history, however, came with no fanfare. Scarcely two weeks after the arrival of the first settlers on the Island of Jamestown in 1607, the pioneers had carved new habitations out of a virgin land, and were planting seeds of vegetables and trees brought over from the Old World. On the other side of the continent the early Franciscan fathers planted fig, grape and olive in California where they still persist today.

Fig. 17. An old Beech tree at Newbattle, England. (From Elwes & Henry, *Trees Gt. Brit. & Irel.*, 1906).

Not only Old World species were brought to new grounds for planting, but numerous new species from the hitherto unknown flora of North and Central America were also being introduced into cultivation for the first time. In a brief span of three hundred years, American trees are planted all over the world, and the Black Locust is to become the most widely planted tree of mankind.

Modern Botanical Explorations

The great maritime activities from the sixteenth century onward not only resulted in the discovery of so many lands in the New World but also in the opening up of vast areas in the Old World formerly forbidden to the outside world. Sailors and adventurers were soon followed by botanical explorers in quest of new plant resources. Their interests were at first largely centered around economic plants and plant products, but later the interest was extended to ornamentals and subjects of pure botanical significance.

The New World of course, revealed an entirely different flora and vegetation, both as to cultivated as well as spontaneous plants. It is not necessary to emphasize here the great impact on the Old World economy made by such crop plants from the Americas as maize, potato, tobacco and many others. Numerous trees from America were also introduced and planted, and altered much the scenery of many Old World cities and gardens. Suffice to say that to this day exploration in the New World is still being actively carried on as vast areas in Central and South America remain little known botanically.

Botanical exploration in the Old World in the nineteenth and twentieth century has also revealed, among other things, the extremely rich flora of temperate eastern Asia in China and Japan. Not only that cultivated plants of economic or ornamental significance are numerous there, but the more remote mountainous districts are found to contain flora that is richer than any other part of the temperate world. Many of the species have since been introduced into cultivation, trees, flowering shrubs and herbs that have contributed greatly toward tree-culture and horticulture of the entire world.

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Arboretum Activities

The Staff

The Director has been invited by Dr. Detlev W. Bronk, President of the National Academy of Science and the American Research Council, to serve on the newly formed Advisory Committee of the Office of Documentation. The purpose of this committee is to study the world-wide problems of scientific documentation.

On Sunday, May 15, the Director lectured before the Philadelphia Chapter of the Cactus Society which holds its monthly meetings at the Arboretum. The subject of his talk was "A Botanist in Mexico." On May 22 he was the principal speaker at the annual meeting for the Friends of the Tyler Arboretum at Lima, Pennsylvania. His topic was "The Nature and Functions of an Arboretum."

Dr. H. L. Li gave the course on the Taxonomy of Angiosperms in the Department of Botany.

Dr. Patricia Allison presented a series of lectures on Fungi in the course on Comparative Morphology of the Lower Plants and also lectured in the course on Mycology.

Holly Society Meeting

From April 20 to 22 the American Holly Society held its annual meeting in Philadelphia. On Saturday, April 22, the members in attendance spent the morning at the Morris Arboretum inspecting our collection of hollies.

Each visitor was given a mimeographed list of the 115 species and varieties of *Ilex* included in our main holly planting on the slope below the Gates Building. This grouping contains 22 species and a large number of hybrids, varieties and cultivars. For example, in *I. opaca* alone there are 58 named forms and in *I. Aquifolium* there are 26. Members of the staff were on hand to aid the visitors in locating the various forms which they wished to study.

Plant Distribution

The annual distribution of plants to our Associates was held on May 20 and 21 and proved to be a highly successful event. More than 250 of our Associates visited the Arboretum in person to claim the two plants allotted to them. The list of available items included many rare and unusual species and varieties.

Gift of Books

The Library of the Arboretum has recently received a small but choice collection of books on botany and horticulture from the estate of the late Morris L. Cooke.

This valued gift was made possible through the generosity of Mr. Cooke's niece, Mrs. Charles O'Connor of Chestnut Hill.

J. M. F., Jr.

Gibberellin: A Growth-Promoting Substance

Edith C. Gall

History

We have been hearing much about gibberellins these last few years. However, the effects of gibberellin were noticed as early as the late 19th century. Since the work had been performed by Japanese scientists and reported in their journals, their observations had been overlooked by western scientsts.

Rice is a very important crop in the Orient. Any disease that affects this crop is important to many people. In 1898 S. Hari (4) a Japanese pathologist in Formosa, studying the diseases of rice, found that an ascomycetous fungus, (*Gibberella fujikuroi* (Saw.) Wollenw.) produced elongation in rice plants. This was given the descriptive name of bakanae disease. The Japanese meaning for bakanae is "foolish."

The manner in which the disease affects the rice plants is very striking. Infected plants become considerably larger than disease-free plants. In the infected plants roots are produced about a foot above the water. From the nodes where these adventitious roots have appeared a cottony fungus forms which later becomes pink. Slightly diseased plants can survive to heading, but they produce fewer spikelets and a smaller panicle; severely diseased plants either die before heading or, if they survive, the panicles they produce are sterile.

E. Kurosawa, in 1928 (4) reported that rice developed symptoms of the disease after treatment with filtrates from cultures of the pathogen, and in 1935 (5) reported that he had isolated an active crystalline material.

It was not until after the war that this Japanese work became known to western scientists and since 1951 considerable research has been carried on. Much credit is given to Frank H. Stodola, of the United States Department of Agriculture, who compiled the first lengthy collection of abstracts on this work (4).

Through the renewed efforts of British, American and Japanese scientists, it was discovered that the active crystalline material isolated first by the Japanese was not a pure product but actually contained four active substances, one of which is now known as gibberellic acid. All these compounds are closely related, being tetracyclic dihydroxy compounds, but cause slightly different reactions. It has been mentioned that the complex lactone ring is essential for biological activity.

Effects of Gibberellin

The effects of gibberellin on plants have been noted from various sources. The most prominent effect has been the increased vegetative growth. This kind of growth shows itself in many ways. The stem may become longer, leaves may develop a different size or shape, the root growth may be altered, and there frequently are changes in the fresh weight or dry weight.

Stem Elongation. Ascertaining how this unusual stem elongation takes place has been a subject of research. Does it occur because of increased cell division or because of cell elongation? It has been generally conceded that with annual plants especially, it is a matter of cell elongation. Work done by S. H. Wittwer on woody ornamentals has proved also that cell division occurs (3). When *Ligustrum obtusifolium Vicari* was subjected to concentrations of 10, 100 or 1000 parts per million of gibberellin applied in a single foliar application in early May, there was a marked increase in terminal growth with increasing concentration (Figure 18). However, when sprays of 100 ppm of gibberellin were applied weekly during the growth period, there was far greater growth than with the other treatments. Furthermore, it was found that the internode length increased and was maximum for 100 ppm applied weekly and that the number of nodes on plants that grew the most was greater than in the untreated controls. This could come about only if there were cell division. Even though there were these greater increases in growth of stem, the gibberellin treatments also produced various injurious side effects.

Further evidence that cell elongation takes place was shown in the work of Kato in 1955 with *Lilium longifolium* (4). Gibberellin markedly stimulated pollen germination. Since the pollen tube involves a single cell, this, then could only take place by elongation.

There is also additional evidence that increased cell division can take place as well as cell elongation. Sachs and Lang in 1957 learned from microscopic examination that there is an increase in the number of cell divisions in the subapical region of nonvernalized rosettes of the biennial *Hyoscyamus niger* (henbane). It was also noted that the cell length increased only four times in a shoot which lengthened over thirty times. Lang further observed that the stem internodes are

practically non-existent in the rosette plant and therefore concluded there must be additional cell division before cell elongation.

Additional Effects of Gibberellin. Gibberellin acts differently from auxin on decapitated sunflower and tomato seedlings. With auxin callus is formed showing cell division, but with gibberellin no callus is formed.

The leaves of treated rice plants were shown to be longer and narrower than in normal rice. It has also been noted that the leaves become yellow because of a lack of root growth to support the increased top. However, this deficiency can be overcome by increasing the use of fertilizer during this period. It has been shown that there is reduction in length, weight and number of roots.

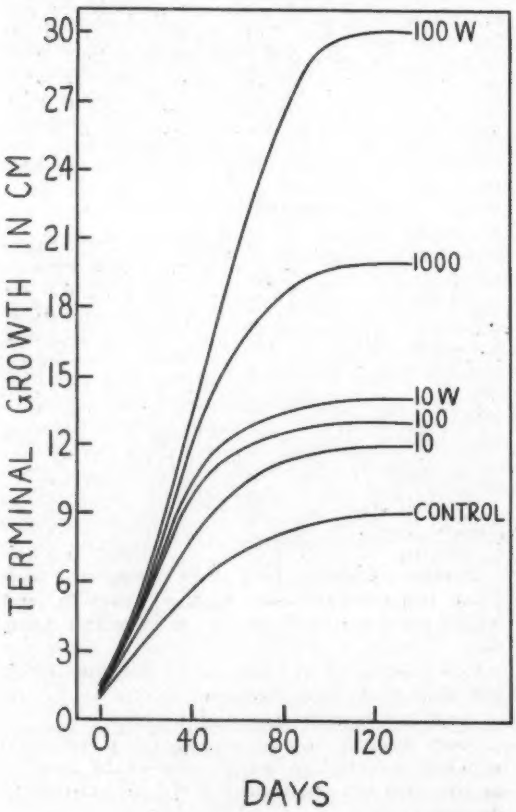

Figure 18. (Data of McVey and Wittwer) Growth in length of terminal shoots of *Ligustrum obtusifolium Vicari* sprayed with gibberellin. Numbers indicate the concentration in ppm. 10W and 100W signify weekly applications. (1)

Growth responses of celery twenty-five days after sprays of varying concentrations of gibberellin were reported by Wittwer and Bukovac (6), (Table 1).

Table 1

(Wittwer and Bukovac) Growth Responses of Celery 25 Days after Spraying with Gibberellins

Concentration ppm	Petiole Length cm	Plant Height cm	Fresh Weight gm	Dry Weight gm
0	13.2	27.2	13.2	1.01
10	17.2	33.5	18.5	1.38
100	19.8	36.8	19.2	1.41
500	19.7	38.2	20.5	1.54
1000	20.8	36.5	16.0	1.13

The significant increases shown here are in both fresh weight and dry weight. They have increased up to 50 per cent. Two to three weeks after spraying another variety the leaf petiole increased in thickness and the length was doubled.

It has been suggested that the increased rates of growth in size and weight were the result of either increased rate of photosynthesis or more efficient utilization of photosynthetic products. Haber and Tolbert (2) studied the photosynthesis in gibberellin-treated oat leaves, utilizing radioactive carbon dioxide. The rate of $C^{14}O_2$ fixation by leaves two hours after beginning gibberellic acid treatment ranging from 1 to 1000 ppm was not significantly greater than that of the untreated leaves.

Other effects of gibberellin have also been noted. One of the more spectacular was the observation of Brian and Hemming in 1955 that dwarf plants were converted into tall plants (4). Phinney in 1956 (5) reported a similar result with dwarf mutants of corn, and Wittwer and Bukovac had similar results with dwarf peas (7).

Gibberellin has a marked influence on fruit production. Grapes when treated gave a higher yield and better quality. Tomatoes were made to give a better yield by the production of fruit without seeds. Gibberellins were sprayed on the flower clusters or were applied directly to the ovary through the use of a lanolin paste or a water solution. Concentrations up to 1000 ppm were used in testing the effectiveness in setting tomato fruit without pollination. Applications of 100 ppm were most effective in all three types of treatment.

Gibberellin has been used in seed treatment to hasten germination. This lessens the possibility of damping-off, root rot, and weed competition. When soil is treated, more uniform germination of weeds results; therefore a larger percentage of the potential weed population is available at one time for eradication.

Another application of gibberellin not usually considered but still of possible usefulness is the shaping of trees. Relatively high concentrations are used and die-back of shoots occurs. With this same idea in mind, gibberellin has been used in the chemical thinning of peaches, plums and apples.

The production of "juvenile" leaves, as found in the ivies, has occurred after the application of gibberellin.

Breaking of Dormancy

In 1956 (4) Anton Lang noted that gibberellin applied to *Hyoscyamus niger*, a biennial, caused stem elongation and flowering in one year.

That is, the need for cold treatment was eliminated but not the long-day requirement. However, Lona, in the same year, but working with a different biennial, was able to replace the long-day requirement with the use of gibberellic acid under short day conditions. Consequently, it is possible to have certain biennials flowering in one year.

Gibberellin has been used to great advantage in aiding the sprouting of tubers before the customary rest period. Also, certain dormant tree buds can be forced into growth. Thus, if such plants can be forced to grow earlier than would be normal the range in which they can be grown can be increased. This material can be used for speeding propagation. Cuttings taken during or immediately after rapid elongation has occurred will root more quickly than cuttings from "non-juvenile" shoots.

As well as breaking dormancy, gibberellin can also postpone dormancy. If applied just before differentiation of the infloresence, that is, just before flower formation begins, the plant continues to grow vegetatively and does not become dormant at its usual time. This method has been applied in the growing of *Hydrangea* and other ornamentals, such as *Forsythia* 'Arnold Dwarf' and *Phellodendron amurense*.

In general, deciduous trees are more responsive to gibberellin than are conifers; also trees that grow continuously are more sensitive to gibberellin than those that grow by flushes. Maples and tulip trees are very sensitive to treatment.

Is gibberellin formed only by fungi? There is some evidence that there are similar substances produced in green plants. Phinney and West, as reported by Wittwer and Bukovac (7), made ethyl ether extractions of young bean seed and obtained an active substance that evoked a growth response in certain dwarf mutants of maize. This response is indistinguishable from that obtained with two of the chemicals of the gibberellin group.

Possible Uses and Dangers

Some favorable or potential uses for gibberellins on woody ornamentals include: an increase in terminal growth with no loss of aesthetic value (the possibility of two years' growth in one); the same as previously mentioned but with a loss in aesthetic value (to be used by the nurseryman in propagation by the induction of "juvenile" cutting wood on hard-to-root plants); the combination of a gibberellin spray program with pruning for promoting shoot growth from axillary buds so that a dense, compact plant develops in a shorter time; the elimination of pruning in some plants by the killing of terminal meristems; the promotion of growth in dwarf varieties; the abscission or desiccation of flowers on plants which produce obnoxious fruit; and the increase of flower size in some species.

There are some injurious effects that must be noted. Increased growth leads to a spindly appearance and a weak plant. Frequently there is leaf distortion. Also there is more top than the roots can support and chlorosis develops. This can be overcome in some instances by the addition of fertilizer along with the gibberellin treatment. It must also be remembered that gibberellins do not initiate root development.

Methods of Application

A stock solution is prepared by dissolving 1 gram of gibberellic acid in a minimum amount of 95 per cent ethyl alcohol containing 0.1 per cent wetting agent, such as Tween 20, and diluting with water to make one liter of solution. Potassium gibberellate is completely water soluble but a wetting agent is still needed. It is also important to consider the purity of the material. Commercial gibberellic acid has 91 per cent active material, potassium gibberellate 82 per cent. These solutions can be used in spraying.

Another method of application is the use of lanolin pastes. A one per cent paste is obtained by placing 12.5 milligrams of acid into a small vial, then dissolving the acid by warming it with seven drops of a spreader, such as Tween 20, and finally mixing it with one gram of melted lanolin.

Other methods are the use of aerosols which will deliver .05 milligrams per second or the use of fertilizer containing the gibberellin.

Most garden supply stores carry products which give complete instructions on the label as to the dilution required for the concentration desired.

The timing of the application is important to get the desired effect. Also it is frequently better to repeat a low dosage periodically rather than rely on one application of higher concentration (1).

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Book Reviews

THE EVERGREENS. By James H. Beale. Doubleday & Co., Inc., New York. 1960.

EVERGREENS FOR EVERY STATE. By Katherine M-P Cloud. Chilton Co., Philadelphia and New York. 1960.

Two useful books on evergreens appeared at nearly the same time. Both are intended for use by the general reader and home gardener.

The first book carries on the jacket the following legend: "How to select, plant, transplant, cultivate and care for all types of evergreen trees and shrubs" and the latter "How to select and grow evergreens successfully in your own locality". The purpose of both is therefore the same, except that the latter puts more emphasis on regional usages. For this it provides a hardiness zone map inside the cover and two reports on evergreen performance from the States and from Canada respectively. Both of these are very useful features.

In both books, broad-leaved evergreens as well as conifers are treated. After general treatises on planting and caring of these plants, both books devote the larger part of the text in describing and discussing the individual groups of plants. Beale's book treats these by families while Cloud's treats these alphabetically by genera. It seems that for general horticultural usage, the latter is a more suitable arrangement for the reader.

Neither of the two books follows the current accepted practice of printing cultivar names in Roman with brackets instead of as Latin trinomials. Cloud's book follows closely the nomenclature of Rehder's classical manual. Although the same manual is also mentioned in the preface to Beale's book, he uses a number of names such as *Pseudotsuga mucronata, Pinus nepalensis,* and others, which are long obsolete. It seems that the value of this book might have been improved upon with the consultation of a botanist as was done with Cloud's book.

H. L. Li

Azalea Petal Blight is in the Philadelphia Area

Patricia Allison

Spring is sometimes slow in coming to Philadelphia. Early crocus gladdens the heart, to be sure, but there is never a rush to put woolens away. Nor does the fragrance of narcissus always tempt a Philadelphian to store a snow shovel. Tantalize as it may, Spring is virtually certain when the azaleas finally begin their splurge. Suddenly Philadelphia vies with Natchez, or Charleston, or New Orleans, as the splendid spectrum of azaleas illuminates May and rhododendrons usher in June.

Even a newcomer can note, however, that one year's display may far outshine another. The azalea bloom at the Arboretum in 1958 was far superior to that of 1959, for example. Last year the colors seemed dim, the season short. This year we know why. The same fungus that in the past transformed the world-famous azalea blossoms of Charleston, South Carolina, into slimy mush in a matter of hours is now active in Philadelphia. Its name is *Ovulinia azaleae* Weiss; the disease is "flower spot" or "petal blight."

History and Distribution

The gardens of Charleston, in 1931, were the scenes of the first noted outbreak. Within seven years other plantings were affected along the Gulf Coast to Texas and up the Atlantic seaboard to North Carolina. These are areas that attract azalea lovers from all parts of the nation. By 1947 the fungus was known in Virginia, Maryland, and California. Until recently its northernmost limit was thought to be Washington, D. C. Then came news in 1956 that greenhouse crops on Long Island were diseased. Now we know that Philadelphia is within the range of the fungus for outdoor plantings, and, judging from the widespread occurrence of the disease this year, the pathogen has been here for some time.

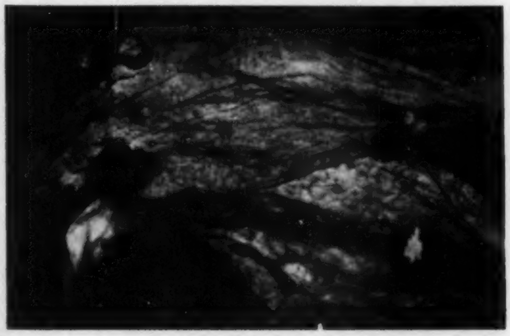

Fig. 19. Dry azalea blossom bearing black sclerotia of *Ovulinia azaleae*.

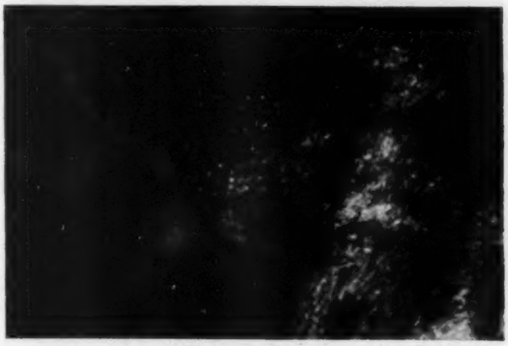

Fig. 20. Azalea petal with "sugar coating" of conidia of *Ovulinia zaleae*.

The Pathogen

It was mentioned that the display of bloom in 1959 was less spectacular than in 1958. This was thought to be a normal seasonal variation, and the possibility of petal blight never was considered until midsummer when definite evidence of the pathogen was encountered. This consisted of tiny, black, cup-shaped fungus structures, called sclerotia, found on flowers that had not fallen from the shrubs (Fig. 19). Dr. Freeman Weiss first described and named the pathogen. He discovered that the sclerotia would remain alive over winter on the ground, and that the environmental conditions prevailing in early spring permitted the development of the next stage in the life cycle of the pathogen. This is a tiny, fleshy fruiting body, the apothecial stage, from which spores are shot into the air. Some of them land on the low-hanging flowers of early-blooming varieties; others are wafted by breezes or rain to additional blossoms. The spores germinate on the surface of the petals and the germ tubes invade the tender tissue from which food

Fig. 21. Conidia of *Ovulinia azaleae* on blighted azalea petal.

As far as is known, the fungus attacks only the blossoms. Despite this fastidious attachment for flowers, the host range among varieties of azalea and rhododendron is broad, and even *Kalmia* blooms are occasionally damaged.

Symptoms

After the microscopic spore starts the cycle, growth of the minute sporling in petal tissue results in a small spot. On white flowers, the spots are brownish (Fig. 23). On colored petals they are paler than the surrounding tissue. If weather permits, the continued growth of the fungus causes rapid destruction of the petals.

Fig. 23. Flower of *Rhododendron mucronatum* with early stages of petal blight.

is obtained. A little later a second type of spore (conidium) is formed by the thousands on the surfaces of the petals. Under slight magnification these can be seen glistening in whitish patches (Fig. 20) or silhouetted at the edges of petals (Fig. 21). Higher magnification is needed to see that each single-celled spore has a tiny suspensor cell attached to it (Fig. 22). Other fungus structures develop at about the same time, but their exact role in the life cycle has not been discovered. Crop after crop of conidia is formed during the flowering period. These spores are carried to other flowers by wind, rain, and even insects. Only after the blossom is well rotted do the sclerotia begin to appear. At first they are whitish curved mats. Later they turn dark, and may fall out of the petal tissue to the ground.

Fig. 22. Conidia of *Ovulinia azaleae*. Note suspensor cell.

The flowers sag and turn brown, plastering the leaves, transforming the shrub into an unsightly mess. (Fig. 24-25). Dr. Cynthia Westcott, who pioneered in the development of chemical control methods, describes the appearance well, saying that the bushes look as if they had boiling water poured over them. If the atmosphere remains moist, the petals are distinctly slimy. Even petals that are only half destroyed fall apart at the touch. This is an important diagnostic characteristic (Fig. 26). Another is the fact that brown areas may still retain a trace of the original small spot (Fig. 26). Still another, is the fact that dead flowers often remain on the shrub, some still attached to the flower stalk, others plastered on the foliage (Fig. 27). Symptoms on rhododendron are similar (Fig. 28-29).

Fig. 24. *Rhododendron mucronatum* and *Rhododendron poukhanense* "Yodogawa", May 11, 1960. Yodogawa bloom is half-destroyed; *R. mucronatum* bloom is spotted.

Control

The fact that *Ovulinia azaleae* causes frequent devastation in southern gardens and is now in the Philadelphia area should not lead us immediately to the conclusion that we must at once begin the same sort of extensive control program recommended for the South. There is the distinct possibility that the fungus is indeed near the northern limit of its range and that we can therefore expect serious trouble only infrequently.

Fig. 25. Same plants as in Fig. 24, May 16, 1960. All blooms destroyed.

For a time, until we know more about the particular symptomology in the Philadelphia area, it will be wise to view all supposed examples of "frost damage," "scorch," and the like with suspicion. Early season marginal browning can very well be caused by the fungus, and the stage may then be set for major collapse of bloom at peak season. Such was the case this year.

Should the experience of this spring prove to be the rule rather than the exception, azalea growers in the Philadelphia area can be both forewarned, through knowledge of symptoms, and forearmed in a very real sense with the knowledge about chemical and cultural control methods supplied us by researchers working in the south and by industries already supplying materials for use in controlling this disease in that area.

Fig. 26. The touch test for Petal Blight. Flower petal of Yodogawa falls apart at the touch. Note minute spots where original fungus invasion occurred.

There are now two chemical approaches to the control of petal blight. One is the application of large doses of fungicide to the ground below the shrubs when they are dormant. This, of course, is to destroy the pathogen before the spring spore ejection begins. The technique was not successful until the recent development of special compounds. Now it may very well prove to be the most important single application of the season.

The second approach has been to protect the flowers themselves throughout the bloom period. Spectacular control has been obtained with the use of zineb and Actidione-RZ. The latter material is now recommended for ground spray also. There is some indication that it may replace zineb as the treatment of choice.

Fig. 27. Azalea blooms reduced to slimy mess by the petal blight fungus.

In the south, floral spraying is begun when the early varieties are in bloom. Sprays are applied three times a week for about a month. I know of no other control technique in which the method of application is so important. Unless the spray itself is exceedingly fine, any of the chemicals that could control the fungus in near-miraculous fashion may actually damage the bloom and new foliage.

Fig. 28. Petal collapse beginning on *Rhododendron obtusum.*

The compounds must be applied as a fine mist – nearly a fog – and wafted toward the blooms from several directions.

It is hoped that such an extensive program will never be necessary in the Philadelphia region.

At present we are suggesting that Philadelphians familiarize themselves with the symptoms of petal blight as much as possible. This should definitely include examination of their own shrubs now. Flowers that are still clinging to shrubs should be inspected for sclerotia, then burned. If the fungus is found, the owner should consider using a ground spray of Actidione-RZ next year. We plan to use this treatment in some beds where the disease was severe this spring.

Fig. 29. *Rhododendron obtusum* flower reduced to limp, slimy mass by *Ovulinia azaleae.*

Remove any dead or diseased bloom from new shrubs next year before bringing them to your garden. Petal blight of both azaleas and rhododendrons was common on plants for sale in various garden centers this year. There is little doubt that the fungus was shipped to us from the South with nursery stock. Even if your garden is not free of it, there is little sense in increasing the population still more.

Rejoice in the knowledge that the results of nearly 30 years of study and research in the South are available to you should the disease prove increasingly destructive in Philadelphia.

Associates' Corner

The Floriade

The Floriade is a great International Horticultural Exhibition now going on in Rotterdam in commemoration of the 400th anniversary of the Tulip. It opened on March 25th and will continue until September 25th. Although principally backed by the Dutch, many other nations are participating, including a large exhibit by the United States.

As the exhibition covers over a hundred acres with greenhouses, pavilions, exhibition halls and waterworks set in a fairy forest of tall trees, landscaped with drifts of flowers and ponds, it would take pages to describe in detail, so I will only touch on a few personal highlights.

The first pleasant surprise was that the posters in public places had a picture of a little child with baskets of flowers somewhat reminiscent of our own Rittenhouse Square Flower Market poster. We arrived at the height of tulip time and all over Holland the streets and houses were decorated with freshly cut flowers, even to the smallest village, and the automobiles and busses were garlanded. Roadside stands of huge garlands for sale added to the gay atmosphere.

Before entering the actual Floriade, a MUST is to go up in the Euromast at one corner of the grounds overlooking the Floriade and the fascinating activities of Rotterdam Harbor.

This is a modernistic tower 400 feet high with a restaurant on top which can accommodate 900 visitors. From here one gets a splendid view of the whole scheme of the Floriade and all the water traffic converging on the vast Harbor from the three rivers. Fortunately, this fantastic mast is to be permanent so, long after the Floriade is a happy memory, one will be able to be whisked up there in a matter of moments and spend hours fascinated by the ever changing panorama.

As a stalwart American, I headed for the United States exhibit first. It occupies quite a large area and what impressed most of the visitors was the house built of native redwood. There were, of course, many other exhibits including a magnificent garden of American grown Iris, but as the captions, when there were any, were in English, and as about only 9 percent of the millons of visitors can speak or read that language, their message failed to get very far. Practically every other exhibit was labeled trilingually.

From here we wandered through that Fairy Forest to the French contribution and then, as time and endurance were limited, we headed for several definite objectives which we had selected beforehand. Naturally they were all at the other end of the grounds. First we took a little open air trolley which deposited us at the highway which divides the area. Here we paused long enough to inspect a group of gigantic aluminum insects such as locusts, beetles, etc. which were made more dramatic by hidden sound tracks imitating their particular buzz.

Climbing into an aerial car suspended on wire we sailed pleasantly over vast flower beds of every conceivable plant, all with museum blooms. Debarking in a floral-draped station we went to the Clusius Garden. The dates on the gate to this charming enclosed garden were 1594-1609, during which time Clusius collected his medicinal herbs. I was surprised to see how many of our present day favorites had been found by him in the 16th century, including tomatoes. From here we went to the "Royal Garden" in a conservatory and which had been contributed by the Kings of Belgium, Greece and Sweden, Queen Elizabeth of England, The Grand Duchess of Luxemburg and Prince Rainier of Monaco. The Monaco exhibit was outstanding. There were masses of stag-horn ferns some 6 feet across and huge china vases at least 5 feet across filled with the most beautiful blooms of *Medinilla magnifica* I ever dreamed of. The whole display was on two levels and the arrangement had a decided Hollywood flare.

Our next objective was the "Biblical Plants and Flowers," section. The terrain was built up to represent an arid part of the world with a cloche-shaped greenhouse of bamboo where olive trees and indigenous herbs and flowers were in appropriate settings. An exceptional touch was glass doors in which Biblical flowers with their leaves and root systems were mounted. I will not go into a description of the miles of greenhouses filled with tulips, peonies and other flowers, or the enormous rose garden with roses from all over the world, but must mention the forests of Amaryllis, all over 4 feet high with blooms as large as a child's balloon.

We wandered slowly back through this dream world really saturated with beauty. At the exhibit gate was a sort of shed with a series of what looked like weighing machines, but on investigating, proved to be electric massage for tired feet. You dropped a coin in a slot and were supposedly refreshed. We did not try it.

It will interest some of our readers to know that the man who is responsible for the over-all design and landscaping of the Floriade is Mr. Meto Vroom, a graduate of the University of Pennsylvania's Division of Landscape Architecture. Mr. Vroom took a number of courses in botany at Penn and in the Summer of 1956 took the course in Woody Ornamental Plants given by Drs. Fogg and Li at the Arboretum.

Marion W. Rivinus

New Associates

The Arboretum is happy to welcome the following new Associates who have enrolled since December 1959:

Dr. and Mrs. William Baltzell
Mr. Joseph Meehan Baxter
Mrs. George Becton
Mr. Martin Brooks
Miss Mary Calwell
Mr. and Mrs. Perry Coleman
Dr. James L. Dannenberg
Mr. William M. David
Dr. Henry M. Drinker
Miss Margaret Earle
Mr. Perry Fairbank
Mr. Joseph P. Flanagan
Mr. Horace Fleisher
Mr. T. Samuel Fleming
Mrs. Eleanor R. Fogg
Mr. Ibri S. Funk
Mr. Wm. J. Germain, Jr.
Mrs. Irvin Gerson
Dr. and Mrs. Herman Gold
Mr. William M. Hanson
Mr. Frank E. Hahn, Jr.
Mr. Ronald L. Harper
Mr. R. A. Hillas
Mr. Richard N. Hood
Mrs. Peter Keating
Mrs. Richard L. Levy
Mr. Arthur D. Lichterman
Mrs. Malcolm Lloyd
Mrs. S. L. Luce
Mrs. A. Basil Lyons
Mrs. George MacLeod
Miss Julia Moore
Mrs. Wm. T. Newbold
Mrs. Henry N. Paul, Jr.
Miss Edith P. Pearson
Mrs. D. Frederick Shick, Jr.
Mrs. Joseph P. Sims, Jr.
Mr. and Mrs. Wm. Wharton Smith
Mr. Gordon S. Smyth
Mr. Jerome Stone
Mrs. Warner Victor
Dr. Adrian W. Voegelin